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Development and Use of Environmental Quality Standards (EQSs) for Priority Pesticides*

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Abstract: The National Rivers Authority (NRA) has a statutory duty to maintain and improve water quality within England and Wales. In carrying out this and other related duties, the NRA needs to identify and prioritise chemicals of concern, including pesticides, with a particular focus on their routes of entry into the aquatic environment. Pesticides can gain access to the aquatic environment *via* both point and diffuse sources and the NRA therefore undertakes monitoring of surface and groundwaters. The NRA publication, 'Pesticides in the Aquatic Environment', summarises the available monitoring data for 1992 and 1993. The significance of pesticide concentrations in surface waters is assessed by direct comparison with Environmental Quality Standards (EQSs) which are designed to give protection to aquatic organisms following acute or chronic exposure. The methodology used in deriving EQSs is outlined, with particular reference to pesticides, together with an indication of how they are used by the NRA and other regulators in pursuit of effective environmental protection. Finally, some key challenges facing pesticide EQSs are considered.

Key words: water quality, legislation, standards, pesticides, environment, EQS

1 INTRODUCTION

The National Rivers Authority (NRA) has statutory duties and powers to protect the aquatic environment from pollution. These duties are contained in the Water Resources Act (1991),[1] which is the primary legislation for water pollution prevention and control within England and Wales. On 1 April 1996 the Environment Agency was established under the Environment Act (1995)[2] and inherited the duties and responsibilities currently undertaken by NRA, Her Majesty's Inspectorate of Pollution (HMIP) and Waste Regulation Authorities (WRAs). The NRA is required to monitor water quality for a wide range of determinands, respond effectively to pollution incidents, control discharges *via* consents and strive to improve environmental quality. One of the key challenges in relation to the protection of surface and groundwater quality is the identification, assessment and control of chemicals released intentionally or accidentally into water. Chemicals gain access to the water environment from both point sources, such as industrial effluents or accidental spillages, and diffuse sources such as agricultural or urban run-off. Whilst the former are amenable to regulatory control or enforcement the latter prove more difficult to deal with and often rely on third-party controls such as marketing and use restrictions. In any event, once chemicals are detected in the water environment, their concentration needs to be compared with some reference level or standard in order for an assessment to be undertaken. This considers many factors, including the nature, concentration and exposure of the chemical involved, in addition to the uses of the receiving water environment.

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2 PESTICIDES IN THE AQUATIC ENVIRONMENT

A pesticide is defined under the Food and Environmental Protection Act (FEPA) 1985[3] as any substance,

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preparation or organism prepared or used for destroying any pest. It is a generic term and covers a wide spectrum of biologically active compounds including herbicides, fungicides and insecticides. There are currently some 450 pesticides approved for use within the UK allied to a range of agricultural and non-agricultural uses.[4] The former accounts for approximately 90% of total use (Thomas, M., 1995, pers. comm.).

Pollution of surface waters and groundwaters from pesticides use is dependent on many variables, including the nature and quantity of pesticide used and possible exposure pathways. The NRA undertakes both statutory and non-statutory monitoring for pesticides and the monitoring programme is routinely reviewed based on regulatory requirements and a comparison of measured concentrations with EQSs.

In 1995 the NRA published a report entitled 'Pesticides in the Aquatic Environment'.[5] This was the first comprehensive report published on the presence and significance of pesticides in the aquatic environment in England and Wales. The report reviewed two years of data (1992/3) derived from NRA statutory and non-statutory monitoring programmes. The dataset consisted of approximately 200,000 annual pesticide measurements gathered from some 3,500 sites and with an estimated cost of £3 million. The main findings of the report were as follows:

- Over 99% of monitoring sites complied with EC List 1 EQSs.
- More than 96% of the monitored sites complied with all EQSs set for 20 pesticides in 1993.
- In surface waters, phenylurea, triazines and phenoxy herbicides predominate.
- Non-agricultural inputs are important.

3 WATER POLLUTION CONTROL OF DANGEROUS SUBSTANCES WITHIN THE EUROPEAN COMMUNITY (EC)

Over the past 20 years the EC and Member States have implemented substance-specific controls through a range of Directives and Regulations aimed at protecting the aquatic environment from the effects of certain chemical pollutants. The first significant legislation to control dangerous substances within the EC was the Dangerous Substance Directive (76/464/EEC).[6] This identifies two broad categories of substances, List 1 and List 2, which require effective control across the Community. List 1 substances are considered to be of greatest concern on the basis of their toxicity, persistence and bioaccumulation and should be eliminated from the aquatic environment. The EC have responsibility for controlling List 1 compounds. List 2 substances are considered to be less harmful and entry into the aquatic environment should be minimised or reduced. Member States have primary responsibility for control of these compounds.

The EC have provided two methods for controlling the release of List 1 and List 2 substances to the aquatic environment. The Limit Value (LV) approach is based on Uniform Emission Standards (UESs) which are applied to all discharges irrespective of the nature of the receiving water environment. These standards were based on what was technically achievable with due regard to economic factors. This system was readily adopted by all Member States apart from the UK who favoured adopting the second approach which involved the use of Environmental Quality Standards (EQSs). The latter are concentration limits which ensure that specified water uses, such as the protection of aquatic life, are protected from the deleterious effects of chemical pollutants.

With respect to List 1 substances, the EC have laid down a number of 'daughter' Directives which specify standards, i.e. UESs or EQSs, for particular substances. A number of heavy metals and pesticides, e.g. DDT, have been considered so far. In relation to List 2 substances, the Member States are responsible for setting standards. The Department of the Environment is the competent authority within the UK.

4 DERIVATION AND USE OF EQSs BY NRA

The EC has responsibility for deriving and implementing EQSs for List 1 substances across all Member States. Within the UK, however, both the DoE and NRA have for many years embarked on deriving EQSs for a wide range of substances through their respective research programmes. In the case of the DoE, priorities have been driven by EC legislation and range of commitments related to various international conventions and Ministerial conferences on the North Sea. The NRA programme has been driven by the need to control and assess the environmental impact of chemicals, from both point and diffuse sources, which are deemed to be of concern in UK surface waters. The EQS derivation process used by the nominated research contractor (Water Research Centre) for both DoE and NRA has been standardised and is outlined in Fig. 1.

4.1 Data gathering

The first stage in the derivation of an EQS for the protection of aquatic life involves a comprehensive literature review drawing on a wide range of information sources including printed texts and databases. Government Departments and industry are also contacted in order to ensure that duplication of regulatory effort is minimised. Information on the following are specifically required for each substance:

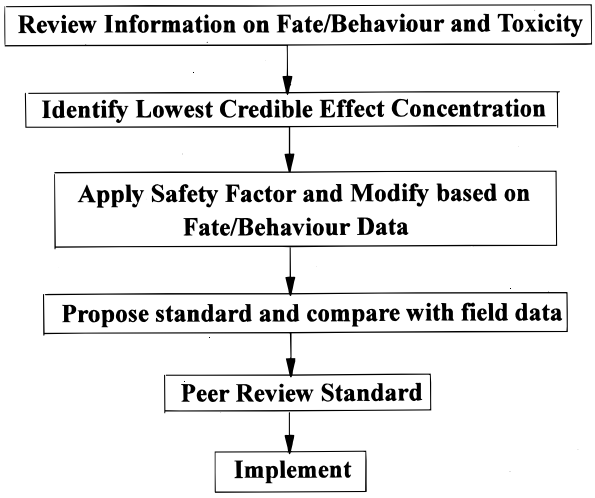

Fig. 1. Derivation of Environmental Quality Standards (EQSs).

— usage and exposure routes;
— physicochemical properties;
— fate/behaviour information such as data on degradation (biotic/abiotic) and bioaccumulation;
— methods of chemical analysis;
— aquatic toxicity data.

4.2 Assessment of data

The minimum data requirements for the derivation of an EQS are based on research carried out by the United States Environmental Protection Agency (US EPA).[7] This indicated that aquatic series sensitivity follows a log-normal distribution and that eight or more data points are required to represent species sensitivity. This should cover both acute and chronic studies spanning the following species:

— algae;
— arthropods (crustaceans/insects);
— non-arthropods (e.g. molluscs);
— fish.

In the case of herbicides, effects on higher plants would also be considered.

The data obtained are often derived from a wide range of tests, using a multitude of test species and measured end points. The quality and relevance of the environmental data used to develop a standard require careful consideration, particularly with respect to aquatic toxicity data. High-quality test data, i.e. those derived from standard tests using recognised protocols, are essential. Other test data are considered on a case-by-case basis and are used to support the high-quality data.

Once all these data have been assessed for quality, the lowest credible effect concentration or highest credible no-effect level is identified.

4.3 Application of safety factors

Safety factors are used in order to account for many variables, including inter and intra-species variation and extrapolation from laboratory studies to the real environment. The safety factor applied depends on the quality and size of the dataset available, along with factors such as the type of data, i.e. acute or chronic, or how the standard is to be expressed. EQSs can be expressed either as a Maximum Allowable Concentration (MAC) to protect against short-term exposure, e.g. a pollution incident, or as an Annual Average (AA) to protect against long-term exposure, e.g. a continuous discharge. Standard safety factors of 100 and 10 can be applied to acute and chronic effect data, respectively. The safety factor applied may be reduced if there is a large, high-quality data set. Sometimes other endpoints, such as No Observable Effect Concentration (NOEC) are used in order to derive an EQS. The latter could be considered as a field NOEC and would normally include a safety factor of less than 10, depending on factors such as acute/chronic ratios. Compounds which are shown to be persistent or bioaccumulative may attract an additional safety factor. This particular stage of the derivation process is vital and relies heavily on scientific judgement and expertise: it is essential that the decision-making process is clear and transparent.

4.4 Comparison with field data

Once an EQS has been derived from laboratory and sometimes mesocosm data, it is compared to measured environmental concentrations and effects. Any anomolies are thoroughly investigated. These may arise, for example, if biological effects are observed at or below the proposed EQS, indicating that the standard may not be stringent enough. The opposite can also be true, although in most cases there are insufficient data to modify the proposed standard based on reliable field observations.

4.5 Peer review

This process is carried out through a steering group which consists of technical experts from government departments and industry. In addition those companies whose chemical is being assessed are given ample opportunity to comment on the research findings and the implications of the proposed standards. Once this process has been completed the standards are confirmed or further work identified. The latter may involve acquiring additional data or the commissioning of toxicity tests if vital data are missing. Standards are

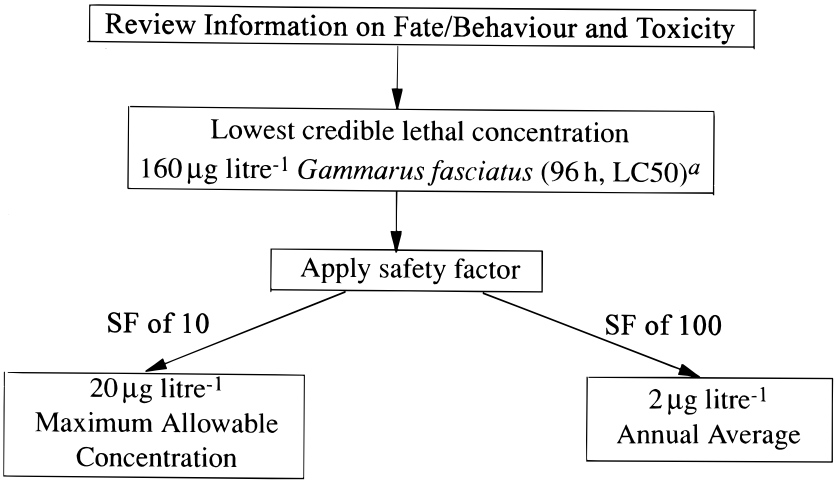

Fig. 2. Derivation of an EQS for diuron.

[a] The proposed EQS was based on a study on *G. fasciatus* as, although algae were identified as being the most sensitive species, the effects were algistatic rather than algicidal and the proposed EQS is sufficiently protective.

TABLE 1
EQSs for Pesticides within the UK

EC List 1[a]	*DoE Proposed Standards*[d]
Hexachlorocyclohexane	Tecnazene
DDT	Dimethoate
Pentachlorophenol	Omethoate
Aldrin, Dieldrin, Isodrin, Endrin	MCPA
Hexachlorobenzene	Bromoxynil
	Ioxynil
DoE List 2[b]	Triazophos
	Thiabendazole
Tributyltin compounds	Demetons
Triphenyltin compounds	Chlorothalonil
Mothproofers (e.g permethrin, cyfluthrin)	Carbendazim
	Chlorpropham
UK Red List[c]	Methiocarb
Atrazine	
Azinphos-methyl	*NRA Proposed Standards*[e]
Dichlorvos	Diazinon
Endosulphan	Chlorfenvinphos
Fenitrothion	Chlorotoluron
Malathion	Isoproturon
Simazine	Diuron
Trifluralin	Linuron
	Cypermethrin
	2,4-D
	Mecoprop

[a] Statutory standards laid down in Daughter Directives of the Dangerous Substance Directive (76/464/EEC).
[b] Standards proposed by the Department of the Environment under the Dangerous Substance Directive (Listed in DoE Circular 7/89).
[c] Standards proposed by the Department of the Environment for the substances appearing in the UK Red List.
[d] Standards proposed as part of the Department of the Environment priority substances programme.
[e] Standards proposed by the National Rivers Authority to meet operational requirements.

referred to as 'tentative' or 'guideline' if outstanding data requirements remain.

4.6 Implementation

The outputs from the NRA EQS research programme are normally made available externally through the Foundation for Water Research (FWR) as well as being widely disseminated within the NRA. The herbicide diuron is one of the compounds that has been considered within the NRA programme and the derivation process for this compound is outlined in Fig. 2.[8] EQSs are used by water quality staff in carrying out a range of activities such as discharge control, pollution incident management and general assessment of environmental quality. Whilst the standards are not currently statutory, they are robust and scientifically defensible and enable NRA to take a balanced view on the impact of individual chemicals on the water environment from both point and diffuse sources. With respect to pesticides, the NRA monitors compliance against a range of EQSs (Table 1).

5 FUTURE OF EQSs WITHIN THE UK

Over the next few years there will be a significant change in the legislation governing the use and release of dangerous substances, including pesticides, into all environmental media. In addition, the need for harmonisation and integration of pollution-control strategies across the EC has facilitated constructive dialogue between Member States who have traditionally relied on either technologically based standards (UES) or the EQS approach. The future introduction of a Directive on Integrated Pollution Prevention and Control (IPPC) coupled with a revision of the current Dangerous Substance Directive is likely to have a profound effect on the multi-media control of chemical releases at EC and UK level. In 1991 the Council of the OECD (Organisation for Economic Co-operation and Development) adopted a recommendation that member countries use a more integrated approach to pollution prevention and control.[9] This recognises that control of chemicals in one medium can result in damage elsewhere.

Risk-based approaches for chemicals such as those outlined in the Existing Substances Regulation (793/93/EEC)[10] and the Directive on Plant Protection Products (91/414/EEC)[11] are important new developments which will undoubtedly shape how standards such as EQSs are derived in the future. The Royal Commission on Environmental Pollution (RCEP) has recently embarked on a major review of environmental standards which will focus on many issues related to EQSs and other standards ranging from their scientific integrity to how they are perceived by the general public.

6 DISCUSSION/CONCLUSION

The UK has more than 20 years experience in the derivation and implementation of EQSs for the protection of aquatic life. This approach has proved its value in the control of both point and diffuse sources, especially with high-priority groups of chemicals such as pesticides. The methodology used to derive EQSs is scientifically defensible, although the lack of relevant chronic effect data and reliable exposure data may necessitate the use of large safety factors. The control of chemicals through the use of EQSs is, of course, substance-specific and hence does not consider the combined effects of chemicals such as synergism and additivity. The challenge for the UK, and particularly the Environment Agency, will be to achieve cost-effective multi-media environmental protection using an integrated pollution prevention and control strategy which is risk-based and can be applied to both substances and mixtures.

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